UV NEWS

The official newsletter of the Thematic Network for Ultraviolet Measurements

Issue 5 / October 2000

HELSINKI UNIVERSITY OF TECHNOLOGY

Contents

ISSN 1456-2537

Picaset OY, Helsinki 2000

UVNEWS is the official newsletter of the Thematic Network for Ultraviolet Measurements. The Network is funded by the Standards, Measurements and Testing programme of the Commission of the European Communities, as project number SMT4-CT97-7510. *UVNEWS* is published twice a year. It is aimed to exchange knowledge between the participants of the Network and to disseminate information on the forthcoming and past activities of the Network. The newsletter also contains scientific and technical articles on UV measurements and a news-section about activities in the field of UV measurements. The newsletter welcomes all announcements and articles that might be of importance for the readers. Material to be published in *UVNEWS* should be sent to:

Helsinki University of Technology
Metrology Research Institute
Petri Kärhä
P. O. Box 3000
FIN-02015 HUT, Finland

Telefax: +358 - 9 - 451 2222
E-mail: petri.karha@hut.fi

In case of longer articles or announcements, use of E-mail is preferred. This is the last regular issue of *UVNEWS* funded by the Commission. Therefore, the date of the next possible issue is not known.

(*Photographs: Cover – Participants of the Borås workshop, page 4 – participants of the WG 1 meeting*)

Co-ordinators column

Erkki Ikonen
Co-ordinator of the Thematic Network

Four years ago none of us knew what a Thematic Network would be in practice. Now we know and it has been an interesting experience. Many activities of the Network could be brought into a successful conclusion in the recent fourth workshop, although some work still needs to be done before mid-November which is the official end point of the EU-funded part of the project. Furthermore, continuation of many Network activities was agreed, most notably the fifth Workshop to be arranged in 2002 in Greece.

One of the most significant features of the Thematic Network is its Working Groups. The Working Groups have allowed the participants to bring up specific topics of their immediate interest. Working Group 1 has produced a document "Characterizing the performance of integral measuring UV meters" which also contains the solutions developed within Working Group 3. Working Group 2 has concentrated on calibration problems and uncertainty budgets of spectrally resolved UV measurements. Working Group 4 has produced a set of documents on UV measurements related to sunbeds. The Working Group documents will be published in a special issue of *UVNews* in November. I am convinced that the documents will strongly influence the future development and standardisation work in the field of UV radiometry.

All Working Groups have decided to continue their operation in 2001. The Working Group leaders will inform the participants on the future activities within their Working Groups.

The Thematic Network also developed a training course intended for industrial technicians and new people in the field of ultraviolet radiation measurements. The prepared course material will serve as a model for future regional training courses. The material will be made available by NPL at a modest price. (For further details, see page 31).

The Network web pages (http://metrology.hut.fi/uvnet/) contain all the earlier issues of *UVNews*, meeting minutes, annual reports, action spectrum database, mailing lists, and announcements for future events. The pages will be updated regularly by Petri Kärhä. Please follow the web pages to be informed of the future activities of the Network.

Finally, I want to express my warmest thanks to all those people who have contributed to the success of the Network over the years. The efforts of Workshop organisers, Working Group leaders, and lecturers of the training courses and workshops are invaluable. The financial support of the European Commission within the SMT Programme is gratefully acknowledged.

I am looking forward to seeing all of you in two years in Greece!

The co-ordinator is with
Helsinki University of Technology
Metrology Research Institute
P.O.Box 3000
FIN-02015 HUT
Finland

Telephone: +358-9-451 2283
Telefax: +358-9-451 2222
E-mail: erkki.ikonen@hut.fi

The Fourth Workshop in Borås, September 6 - 8, 2000

Petri Kärhä
Helsinki University of Technology, Finland

The fourth workshop of the Thematic Network for Ultraviolet Measurements was arranged at SP, Swedish National Testing and Research Institute in Borås, Sweden on September 6-8, 2000. The number of participants in the workshop was 47, somewhat less than in earlier workshops.

Half of the first day (Wednesday) of the workshop was dedicated to a satellite meeting *3rd International Workshop on Detector-Based UV Radiometry* chaired by Hans Rabus of PTB, Berlin. A detailed report on the achievements in this workshop can be found on page 24 of this *UVNews*.

On Wednesday afternoon, there was a guided tour to the various laboratories of SP. For most of us, the most remarkable thing to see was probably the huge hall used for solar exposure. The high power radiation of the lamp-covered roof brought memories of summer for all of us. For us Finns, the most pleasant surprise was the big weather room, the climate of which was close to the conditions in a Finnish sauna, except a bit chilly.

The main topic of the workshop was finalising the documents being produced by the working groups (WG). The working groups had their meetings on Thursday morning, and the results were presented in the afternoon. The most advanced of the working groups is WG 1, of which we owe big thanks to its leader, Anton Gugg-Helminger of Gigahertz Optik. WG 1 accepted in their meeting the produced document "Characterizing the performance of integral measuring UV meters" with only minor corrections to be made after the workshop. This document will be used as background when standardising work in the area is carried out in the future. WG 2 has gathered a massive amount of information to be included in their final document. Analysing and preparing the input is a huge task, but the members of the WG expect to finalise their task just in time. Despite the lead of WG 1, it was WG 4 who actually managed to complete their task first. The finalised document "UV Measurements Related to Artificial Tanning Units" has already been finalised and put forward. The outcome of all WG's will be published in a special issue of *UVNews* in November.

Despite the somewhat low number of participants, the scientific contents of the workshop were high. In the poster session on Thursday afternoon, the 8 presented posters generated fruitful discussions. The abstracts of these presentations may be

The author is with
Helsinki University of Technology
Metrology Research Institute
P.O.Box 3000
FIN-02015 HUT
Finland

Telephone: +358-9-451 2289
Telefax: +358-9-451 2222
E-mail: petri.karha@hut.fi

found in the web pages of the network. The best poster award was given to Merete Hannevik of Norvegian Radiation Protection Authority, for presenting the poster “Survey of tanning studios in Norway,” by E.G. Björklund, B. Johnsen, M. Hannevik and L.T. Norvang.

The whole Friday morning was reserved for presenting the status of the EU-funded project “Improving the Accuracy of Ultraviolet Radiation Measurement” co-ordinated by Neil Harrison of the NPL, who also chaired the session. The session was very useful for both the audience, who learned about the project, and the speakers, who got useful input and important views for the project. A report on the project prepared by Neil Harrison can be found on page 18 of this *UVNews*.

The Friday afternoon was reserved for four scientific presentations:

- Intercomparisons and equivalence (Rainer Köhler, BIPM)
- The use of photometric and UV transfer standards in lighting industry (Anton Bouman, Philips)
- The solar UV-instrument Intercomparison NOGIC2000 and preliminary results (Ulf Wester, SSI)
- State of art in technologies (Nigel Fox, NPL)

The final culmination for the workshop took place in a debate generated by Ulf Wester’s presentation. The excellent agreement reached in a solar UV-instrument intercomparison generated doubts among the participants from national standards laboratories. The comments given by both sides showed that we, the participants of the network, have lots to learn from each other. It was therefore a pleasure to get an agreement on the continuation of the activities of the network in this workshop. All WG’s will continue more or less actively, and a fifth workshop will be arranged in year 2002.

The local organisers at SP, especially Leif Liedquist and Britta Stålhammar, did an excellent job in arranging the workshop. This was of course recognised in the talks at the workshop dinner on Thursday evening. Nordic countries may be somewhat cold to arrange meetings in autumn, but the warm hospitality of the organisers compensated this to a large extent. On behalf of us participants, I would like to thank Leif and Britta one more time!

Many authors of the scientific presentations used their opportunity to publish extended abstracts of their presentations. These extended abstracts may be seen in the following section.

Extended Abstracts

The Solar UV-instrument Intercomparison NOGIC2000

Ulf Wester
Swedish Radiation Protection Institute

An international solar UV-instrument intercomparison "NOGIC2000" was hosted by Sweden during the summer. The event took place on the roof of a beach-hotel at Tylösand close to the city of Halmstad at the Swedish west-coast June 9-16, 2000. The intercomparison was arranged within the Nordic co-operation NOG – the Nordic Ozone and UV Group - formed by Nordic meteorological institutes, radiation protection institutes and university departments involved in ozone- and solar UV-measurements. An important part of the NOG co-operation is to share experiences from measurements and to facilitate improvements. In this context the group carries out instrument intercomparisons, i.e. solar UV-instruments are compared simultaneously at the same time, place, conditions of sunlight and weather. There have been three previous NOG-intercomparisons - in Norrköping 1991 and on Tenerife 1993 and 1996.

In the campaign of NOGIC2000 at Tylösand, sixteen groups/institutes, a total of 31 persons from Norway, Finland, Sweden, Austria, The Netherlands, Canada, Poland and Germany participated with 14 spectroradiometers and a number of other broad-, narrow- and multi-band instruments.

Figure 1. View on the intercomparison site on the roof of the hotel.

The instruments are normally used for continuous measurements at home-sites of the participating institutes in the respective countries. They monitor the stratospheric ozone layer and the solar UV radiation at ground-level. That is essential for reports of the UV-index and for the check of the environmental impact of ozone depleting gases e.g. CFC's and their release-restrictions.

Figure 2. Analysis of the data took place in real-time in the formed data-analysis centre.

The author is with
Swedish Radiation Protection Institute
Div. of Environmental Monitoring & Dosimetry
Non-ionizing radiation
SE-17116 Stockholm
Sweden

Telephone: +46-8-7297171
Telefax: 46-8-311714
E-mail: ulf.wester@ssi.se
http://www.ssi.se/

The Scandinavian summer weather during the campaign varied from days with totally clear sky, to days with rapidly changing cloud conditions or days with overcast and some rain showers. The intercomparison was successful, and possibly some of the best spectral instruments may have agreed within three percent, but the results remain to be analysed and eventually reported.

NOGIC2000 was arranged and partly sponsored by the Swedish Radiation Protection Institute (SSI) and the Swedish National Testing and Research Institute (SP).

First results of long-term ground-based measurements of solar UV radiation in Germany

M.Steinmetz, R.Matthes, and P.Hofmann*
BfS,Germany

1. Abstract

This spring and early summer very high UV levels were measured In Northern and Middle Europe, less than the years before. These high levels were the result of very low ozone values in the upper atmosphere. So, continuous monitoring and radiation hygienic assessment of solar UV radiation become of increasing importance.

Since 1994 the Federal Environmental Office (UBA, Berlin) together with the Federal Office for Radiation Protection (BfS, Salzgitter) measure continuously and spectrally resolved solar UV irradiation in Munich, Frankfurt, in the southern black forest and at the Baltic sea.

Till now no expected significant trend in increasing UV exposure can be observed due to big changes in the yearly meteorological conditions. Nevertheless there are many days with erythemal weighted UV doses of 250 J/m²/30min round high noon.

2. Monitoring network

Since 1994, the Federal Environmental Office (UBA, Berlin) together with the Federal Office for Radiation Protection (BfS, Salzgitter), has been operating on a national UV monitoring network nation-wide for the continuos measurements. The major tasks involved are:

- reporting on the levels of current and future solar UV exposure,
- assessing the effects of changed levels of UV irradiation from a human health point of view,
- providing the population with guidelines for appropriate early protection.

The network consists of a reference station (Fig. 1a) in Munich-Neuherberg, the tasks of quality control and assurance for all data, and of 3 further measuring stations. In deciding these sites, the personnel and equipment related internal structure of the participating institutions was taken into considerations, along with the different latitudes, climatic conditions and environmental burdens in the troposphere. In association with four more institutions most important regions of Germany are covered.

3. The measuring device

All sensitive components (monochromator and electronic devices) of the measuring system (Fig. 1b) operate under stable laboratory conditions. The system is connected optically via a 4 m long light optical fibre bundle with the entrance optics mounted on the roof of the building. The most important measuring specifications are as follows: measuring time is every 6 min, from ½ h after sunrise to ½ h before sunset. Measuring a spectrum needs ca. 90 sec. The system sensitivity is 1 µW/m² with a bandwidth of 1 nm.

* The corresponding author is with
Bundesamt für Strahlenschutz
Institut für Strahlenhygiene; Abteilung S2.5
Postfach 1108
DE-85758 Oberschleiszheim
Germany

Telephone: +49-89-31603235
Telefax: +49-89-31603111
E-mail: msteinmetz@bfs.de

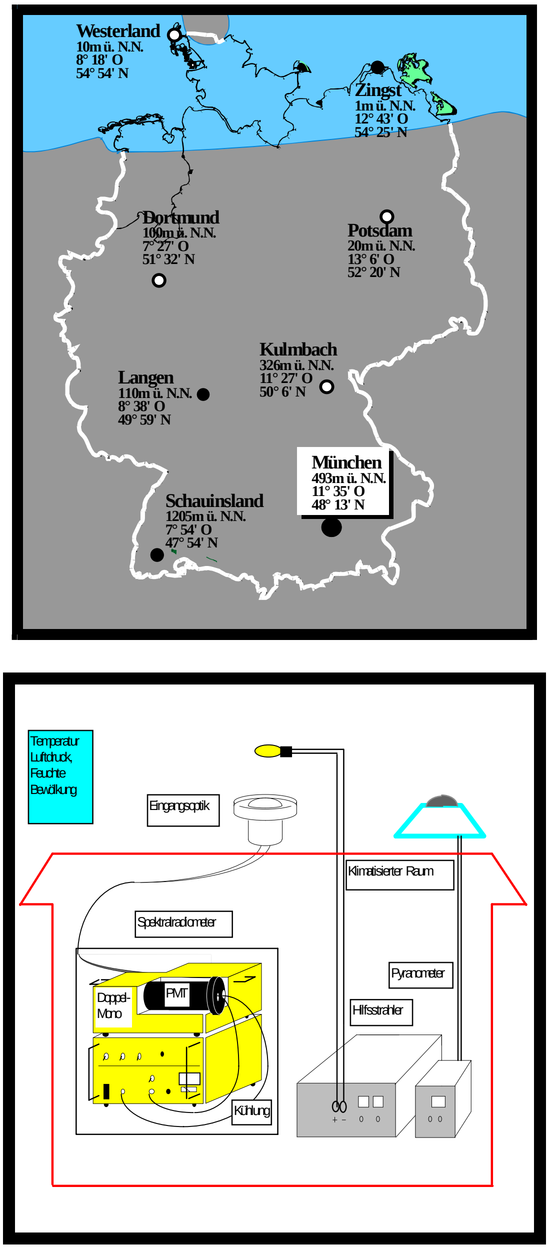


Figure 1. a) Solar UV-Monitoring network of BfS/UBA (Filled circles) with 4 associated stations (Open circles). b) UV measuring station. The parameters of temperature, pressure, humidity and cloudiness are delivered by the German Weather service (DWD).

The system sensitivity is calibrated every 2 - 3 months with a 1000 W halogen lamp unit developed at the BfS. To supplement the regular calibration procedures the system measures every night spectra from an automatic 35 W auxiliary lamp system that are compared with the spectra of previous nights. Earlier data show a long-term variability in the sensitivity within a range of 2 %. In order to achieve high technical standards, continuous hardware and software improvements are made to the equipment operated at the reference station. Furthermore, the reference station will participate in national and international field comparisons.

4. Results

For a preliminary human health assessment, all 6-min spectra are averaged over a ½ - hour period to give ½ hour mean spectra, and subsequently weighted by means of CIE response function. Integration for a wavelength range of 290 – 400 nm, and a time range of 30 min yields the effective half hour exposure dose rate J/m²/30 min, the so called hED.

Figure 2 shows the annual course of the hED values relative to the time of the day for the measuring station Neuherberg. Intervals of 50 J/m²/30min are respectively classified by different colours. From a radiation hygienic viewpoint hED-levels of 250 J/m²/30min and more (UVI>7) mean a very high UV exposure, radiation protection is strongly needed. Last year such a high exposure was measured in Neuherberg between April 20 and September 10, up to 6 hours maximum.

Further, Figure 2 shows a high variation of the plotted hED-values during the year mostly due to changing sun elevation and different weather conditions. To decrease the influence of the weather on the UV values, for documentation daily sums of the hED values are more appropriate. In the time period of 1995 to 1999 Fig. 3a shows the highest erythemally weighted daily sums of the year of all 4 stations. The high fluctuations from year to year are due to values measured at different days with different sun elevations and different atmospheric conditions.

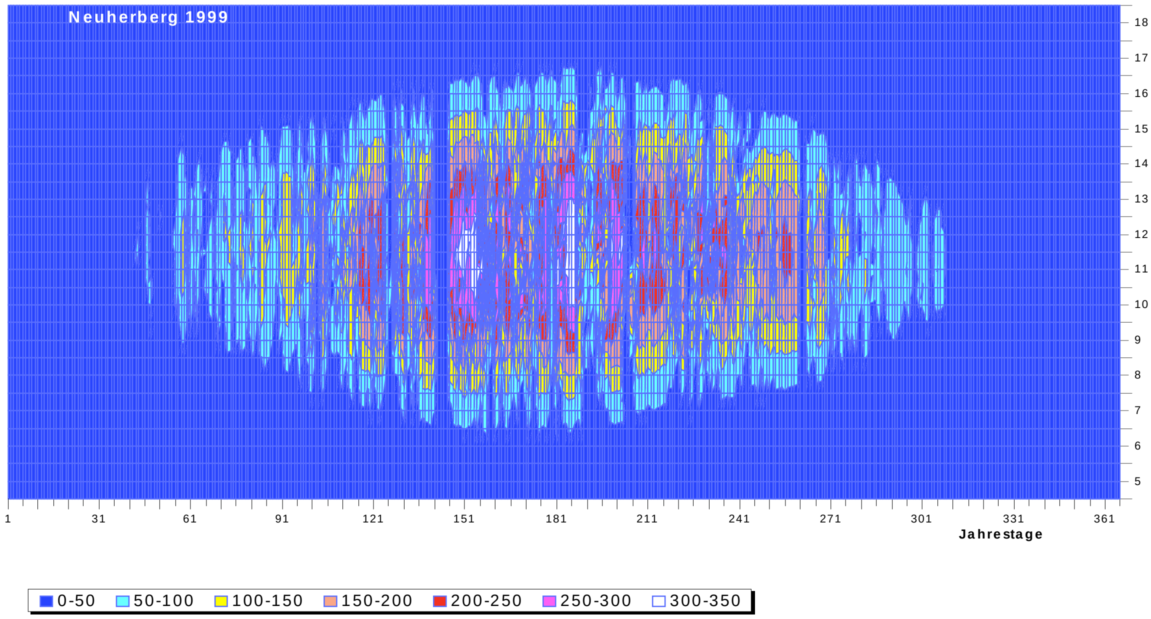


Figure 2. Annual course of hED-values of the station Neuherberg. Intervals of 50J/m²/30min are respectively classified by different colours. Vertical axis: hours in UTC, horizontal axis: day of the year 1999.

In the time period of 1995 to 1999 fig.3b shows the mean erythemal weighted daily sum over the time interval from May to August of all 4 stations. The time period is too short to discuss an possible trend in UV increase, but in comparison to 1995 in general the UV exposure is higher in 1999. Further measurements are needed.

Table 1. UV Index categories.

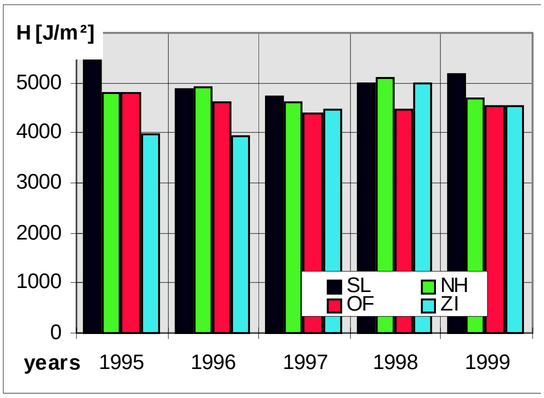
UV Index	Description
≥ 8	UV exposure very high, erythema in less than 20 minutes possible, protective measures are indispensable
5 - 7	exposure high, erythema possible after 20 minutes, protective measures necessary
2 - 4	UV exposure moderate, erythema possible after 30 minutes, protective measures recommended
0 – 1	UV exposure low, erythema unlikely to occur, protective measures not necessary

Nevertheless, this entire constellation provides a good overview of the UV radiation situation in Germany and is therefore an ideal supplement to more detailed studies on biological effects.

5. Public relations

In Germany the Radiation Protection Commission has recommended the use of the international UV Index for public information and education purposes (Table 1). The UV Index range is divided into four categories and recommendations are provided for each category. As individual risk for acute UV effects may vary with skin type, all recommendations are based on untanned skin of type II.

In order to inform the public on the current solar UV radiation UVI levels are forecast and measurements reported for the period from April to September. The UVI prognoses is issued every second day for the coming three days. The message includes the recommendations and include sunburn times. The BfS forecasts are based on a statistical evaluation of our own measured data at nearly identical sun zenith angles and atmospheric conditions, especially with regard to cloud cover. Normal summer ozone fluctuations influence the UVI in the forecast region by less than 10 %. Concerning the UVI classification, ozone fluctuations need not be considered in that evaluation.



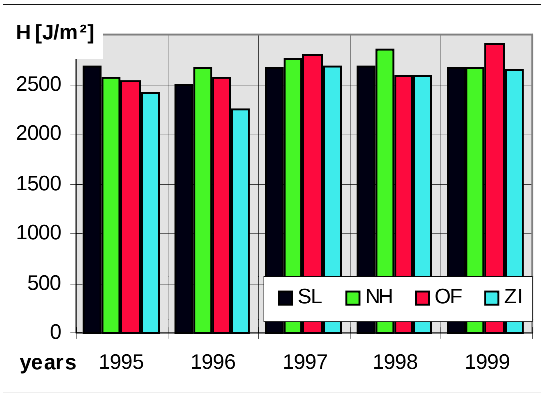
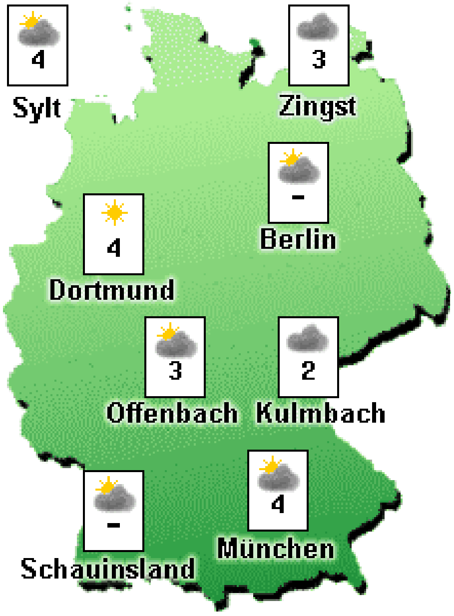


Figure 3. a) Max. erythemal weighted daily sum of the year. b) Mean erythemal weighted daily sum between May and August for the stations Schauinsland (SL), Neuherberg (NH), Offenbach (OF) and Zingst (ZI)



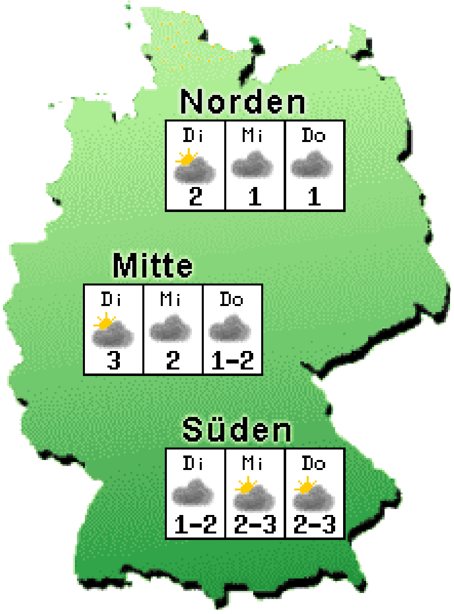


Figure 4. a) Internet presentation of actual UV index values measured at the 8 stations. b) 3 day UVI forecast for the North, Middle and South of Germany

International Instrument Intercomparison of the Biological - UV-Detection Film System Viospor® Versus High Sophisticated Spectroradiometers in a Blind Study - Weighting According MED-CIE or DNA-Damage (Setlow)

S. Kazadzis[1], A. Bais[1], L. Quintern[2], and H. Holtschmidt[2]*
1 Aristotle University of Thessaloniki, Greece,
2 BioSense, Laboratory for Biosensory Systems, Bornheim, Germany

1. Summary

The aim of this project was the intercomparison of the biological UV-dosimeter system VioSpor® (spore film) simulating the MED-CIE (VioSpor® blue-line) or the DNA damage (VioSpor® red-line) response function versus high sophisticated spectroradiometric measurements in Thessaloniki (Greece). This blind study was performed in three periods: June 1998, Oct/Nov 1998, June 1999 (shown in this text). The measurement results demonstrate that the total deviations are in the average below 10 % as long as daily exposures are concerned. This underlines the accuracy of the measuring system VioSpor®.

2. Methods

Measurements were done with the double monochromator Brewer #086 performing spectral measurements of global irradiance in the region of 285 - 365 nm with the step of 0,5 nm and with a full spectral scan every 20 min. Additionally, measurements of a broadband detector (Yankee Enviro-mental System, UVB-1) have been taken every minute. Two different VioSpor®-systems were tested: VioSpor® blue-line simulating the MED-CIE function and VioSpor® red-line simulating the DNA response function (Setlow). With this dose integrating VioSpor®-system hourly, daily and three-day exposures were performed under different conditions of cloudiness, ozone and aerosol concentrations.

* The corresponding author is with
BioSense, Laboratory for Biosensory Systems GbR
Moernerstraße 45
DE-53332 Bornheim
Germany

Telephone: +49-2222-934090
Telefax: +49-2222-934091
E-mail: mail@biosense.de
http://www.biosense.de/

3. Results

Measurements of June '99 have been performed with cloudless sky in most of the cases. Partly clouded days could not be eliminated and could explain the deviations of the compared measurements in some cases (see fig.1). In figure 1 the measurements of the diurnal variation of the global and the direct irradiance measured by the brewer instrument are presented. Additionally the doses measured with the broadband UVB-1 Detector are shown. The changes of the radiation field which were present especially in the afternoon and evening hours are quite well described by both instruments.

3.1. Athmospheric conditions on June 04.1999

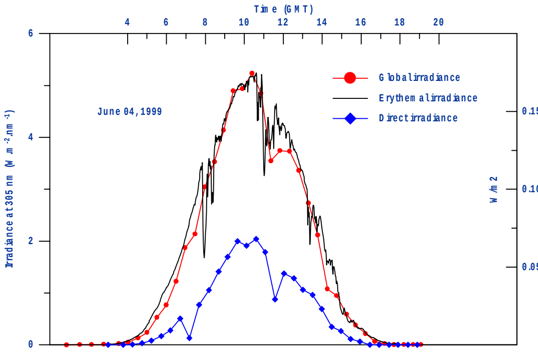


Figure 1. Spectral measurements (305 nm) of the direct (blue line), global

(red line), UVB irradiance and erythemal dose (black line, Yankee detector)) measured at Thessaloniki on June 9, 1999.

3.2. Measurements with VioSpor® blue line dosimeters simulating MED/CIE action-spectrum

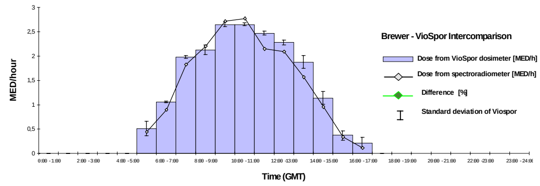


Figure 2. (Down) Measurements of biological dose (MED) with the Brewer spectroradiometer (black line) and with Viospor biological dosimeters (bars) on June 4, 1999. (Up) per cent deviation of the two types of measurements.

Taking into account the results presented for that period, we can conclude that for the dosimeters simulating the CIE and the DNA action spectrum deviations among the two types of measurements reach 6 % for the daily and 11 % for the three-day exposures. The deviations of hourly measurements are within 10 % for solar zenith angles smaller than 75°. Finally bigger deviations (15 %) were found in the cases reaching the lower end of the detection limit of the dosimeters.

3.3. Measurements with VioSpor® red line dosimeters simulating DNA action-spectrum (Setlow)

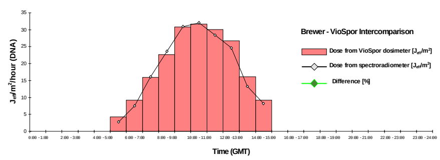


Figure 3. (Down) Measurements of biological dose (MED) with the Brewer spectroradiometer (black line) and with Viospor biological dosimeters type redline simulating DNA spectrum (Setlow) (bars) on June 4, 1999. (Up) per cent deviation of the two types of measurements.

For the measurement with VioSpor® red line dosimeters the similar results were determined as for blue line; in general deviations are among 5-12 % with the same problems appearing for the case of the high solar zenith angles.

4. Summary of blind test results:

- For both VioSpor systems (VioSpor® blue-line, CIE-MED wheighted and VioSpor® red-line, DNA wheighted) the measurement results show that the total deviations are in the average below 10 % for all the cases as long as daily exposures are concerned.

- For hourly measurements with solar zenith angles <75° the deviation was <10 %. At higher zenith angles >75° and low doses that were close to the detection limit of the system deviations of 15 – 40 % were found.

- Measurements performed at cloudy weather conditions or under clear sky showed that there is no difference concerning its accuracy.

4. Conclusions

- Both VioSpor®- data fit well to the values detected with high sophisticated spectroradiometers.

- The biologically film systems (MED or CIE weighted) are especially suitable for the detection of the biologically effective UV-radiation reaching the ground with its effects on humans or other biological systems.

- VioSpor® was easy to handle by persons who were not trained in using the system. The casing is small, light, water resistant and suitable even for personal dosimetry even in solaria and at work place or in leisure time under difficult environmental conditions.

Problems with the classification of UV-meters

A. Gugg-Helminger, E. Krochmann, and S. Fenk*
Gigahertz-Optik GmbH, Puchheim, Germany

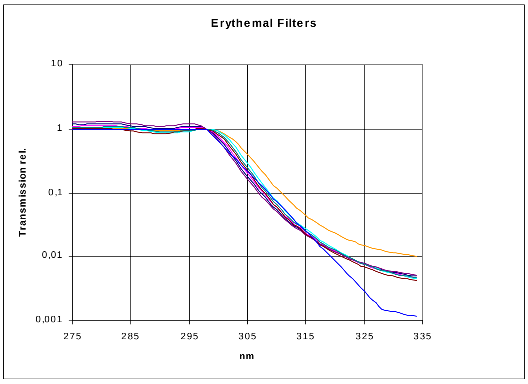
1. Introduction

Only a shift of 3 nm at the edge of the responsivity of an erythemally weighted UV detector head could give an absolute uncertainty of nearly 100 % in the actual measurement. The 3-nm value for the shift is based on measurements of actual available interference filters for erythemally weighted UV-meters. Typical variations vary within +/-3 nm. Knowing the high uncertainty, it can be concluded that it is impossible to produce a perfect detector in high volumes.

The reason for such a high uncertainty can simply be shown with the responsivity curves of erythemally weighted detectors, when measuring different light sources.

The responsivity curves are typically plotted on a logarithmic scale (Fig. 1a). When looking at the logarithmic curves, the sensitivities of the detectors seem to match nearly perfectly to the theoretical curve. All filters except one look very good. Therefore, the customer may think that he has a very good detector unit, and believe that the measurement results are real absolute values.

The reality is revealed if the responsivities are plotted on a linear scale (Fig. 1b). It can easily be seen that the spread among the detectors is high. Such detectors can not measure accurately among all circumstances.



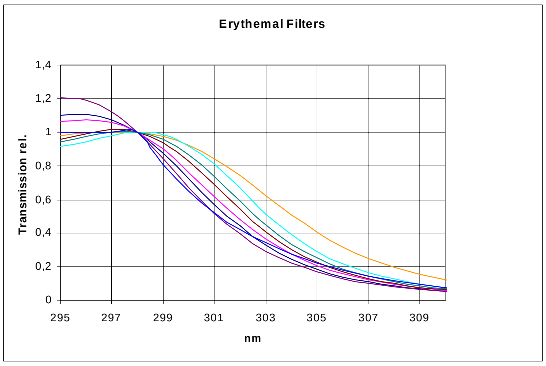


Figure 1. Measured transmittances for erythemal filters to be used in erythemally weighted UV meters. a) Logarithmic plot b) linear plot.

2. Effect of wavelength shifts in lamp measurements.

From Fig. 1, we can conclude that the wavelength uncertainty of the 50 % point of the slope is approximately 3 nm. This value can be used to calculate uncertainties that the meter has, when measuring various light sources. The calculation results are plotted in Fig. 2.

* The corresponding author is with
Gigahertz-Optik
Fischerstraße 4
DE-82178 Puchheim
Germany

Telephone: +49-89-89015920
Telefax: 49-89-89015950
E-mail: gugg-helminger@go-puchheim.de

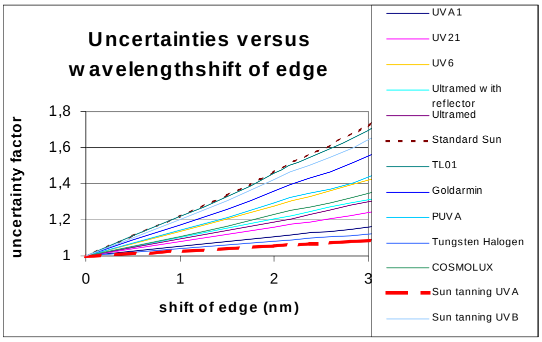


Figure 2. Measurement errors for measuring various light sources with an erythemally weighted detector, as functions of the wavelength shift of the edge.

The correction factor varies a lot from source to source. It is therefore clear that the detector heads cannot be calibrated to measure correctly all kinds of sources.

To enable reliable measurements, it is necessary to give the customer more information about the detector. It does not make sense to classify the detectors in general. To get good measurement results, we now present a proposal on how to characterise detector heads.

3. Calibration of UV- radiometer heads

Since the measurement results vary from source to source, we must define a spectral mismatch correction factor that can be calculated for different light sources and be given in the calibration report. This correction factor is unique for each detector head or readout meter and should be calculated for typical light sources.

The customer can then select the light source he wants to measure, and by applying the specified correction, he will get much better results.

For a good detector the correction factor is very close to 1 for all sources. If a customer uses a detector for only one type of light source, a very poor detector could give very good results, because the correction factor is within the calibration.

3.1. Irradiance

First the effective irradiance $E_{e,act}$ must be determined which results for a considered effect with that lamp used for calibration. For the reference plane it can be calculated according to

$$E_{e,act} = \int_0^\infty E_{e,\lambda,Kal}(\lambda) \cdot s(\lambda)_{act,rel} \cdot d\lambda \,, \qquad (1)$$

where $E_{e,act}$ is the effective (actinic) irradiance of the calibration source at the reference plane, $s(\lambda)_{act,rel}$ is the relative spectral weighting function for the considered effect, and $E_{e,\lambda,Kal}(\lambda)$ is the spectral irradiance of the calibration source at the reference plane.

3.2. Definition of Spectral Mismatch Correction Factor

In order to describe the deviation of an actual source with respect to the source used for calibration, the spectral mismatch error can be calculated for different relevant lamps according to

$$a(Z_x) = \frac{\int_0^\infty E_{e,\lambda,Kal}(\lambda) \cdot s(\lambda)_{act,rel} \cdot d\lambda}{\int_0^\infty E_{e,\lambda,Kal}(\lambda) \cdot s(\lambda)_{rel} \cdot d\lambda} \cdot \frac{\int_0^\infty E_{e,\lambda,Z_x}(\lambda) \cdot s(\lambda)_{rel} \cdot d\lambda}{\int_0^\infty E_{e,\lambda,Z_x}(\lambda) \cdot s(\lambda)_{act,rel} \cdot d\lambda} \,, \qquad (2)$$

where $a(Z_x)$ is the spectral mismatch correction factor for the used source Z_x, $E_{e,\lambda,Kal}$ is the spectral irradiance of the calibration source at the reference plane, $s(\lambda)_{rel}$ is the relative spectral response of the considered radiometer head, $E_{e,\lambda,Zx}$ is the spectral irradiance of the source Z_x at the reference plane, and $s(\lambda)_{act,rel}$ is the relative spectral weighting function for the considered actinic effect.

This figure of merit, $a(z)$ is close to unity, if the matching of the meter is good for measurement of the light source z. It can also be given in form

$$f_1(Z) = a(Z)-1 \quad , \qquad (3)$$

which is close to zero, with good matching.

If a measurement of a source Z_x is carried out, with a radiometer previously calibrated with the calibration source *Kal* , the reading can be corrected according to

$$Y = \frac{Y_{Z_x}}{a(Z_x)} \quad , \qquad (4)$$

where Y is the corrected value, Y_{Zx} is the reading of the radiometer with source Z_x, and $a(Z_x)$ is according to Eq. (2).

4. Conclusions

When using the described methods, it is easy to give correction factors for most lightsources. Typically, technical lightsources are nearly constant in the spectral values versus wavelength.

However, if the spectral distribution of the light source changes, then for every change a correction factor may be necessary. If the correction factor for every lightsource is close to unity, various correction factors may not be necessary.

Factor $a(Z)$ is a good indicator for the quality of a detector head. The user sees at once, if a detector is good for only some light sources (high variation in the $a(Z)$ values) or nearly for all light sources ($a(Z)$ close to unity for all light sources)

Therefore it is recommend for manufactures to inform in the calibration sheet about the relevant figures for $a(Z)$ or $f_1(Z)$.

This is also recommended in the document "Characterizing for the performance of integral measuring UV-meters" prepared by the WG1 the UV Thematic Network, which will be published in *UVNews* **6**.

Improving the Accuracy of Ultraviolet Radiation Measurement

Neil Harrison
NPL, UK

Ultraviolet (UV) measurement is essential in many areas of industry and has important health and safety applications in daily life. Measurement of solar UV radiation, UV sun beds, monitoring of UV sterilisation processes and UV exposure in the work place are all examples where the quantification of the levels of UV radiation are important for health and safety. In many industrial applications the accuracy of calibration and the stability of measurement equipment in the UV now limits the performance and cost effectiveness of production processes. Quality control and waste reduction in fields such as material curing, water purification, non-destructive testing and photolithography of semiconductors all demand reliable and accurate UV measurements to ensure commercial competitiveness. To address some of these issues the European Commission has funded this SM&T project 'Improving the accuracy of Ultraviolet Radiation Measurement' which started in December 1998 with NPL acting as co-ordinator of a team of eight partners from across Europe. The project has the overall objective of improving the accuracy of ultraviolet measurements in both the European ultraviolet measurement community and European national measurement institutes.

Partners

- National Physical Laboratory (NPL, Co-ordinator)
- Physikalisch-Technische Bundesanstalt (PTB)
- Nederlands Meetinstituut (NMi)
- Helsinki University of Technology (HUT),
- Conservatoire National des Arts et Metiers, Institut National de Metrology (BNM-INM)
- Laboratoire National d'Essais (LNE)
- STUK - Radiation and Nuclear Safety Authority (STUK)
- ASM Lithography (ASML)

Introduction

Tackling specific measurement issues in all of the diverse and wide ranging applications where UV measurement is important would be an ambitious and very substantial undertaking. However, building the foundations for improved UV measurement is a more practical proposition. This project was conceived with the objective of establishing some of the building blocks to enable improved UV measurement methods and technologies to be disseminated to the wider UV measurement community. The initial aim was to target specific problem areas in UV metrology starting with improving UV measurement scales and building on this work to improve industrial and environmental UV measurement. Particular objectives of the project are:

- A reduction in base UV spectral responsivity scale uncertainties by a factor of five,
- Improvement in the dissemination of UV spectral responsivity scales through higher quality transfer standards,
- Investigation of ageing of UV detectors and optical components under UV irradiation,
- Improvement of intense UV irradiance measurement for industrial applications,
- Construction and evaluation of an improved calibrator for solar UV measurements.

The author is with
National Physical Laboratory,
Queens Rd, Teddington,
Middlesex, TW11 0LW
UK

Telephone: +44 (0)20 8943 6443
Teleax: +44 (0)20 8614 0411
E-mail: neil.harrison@npl.co.uk

The project has been structured into five work packages. The first work package develops and evaluates new UV filter radiometers and compares calibration techniques for such instruments at different laboratories. Work package two is designed to investigate new UV detector technologies with the aim of developing improved transfer standards followed by a comparison of UV spectral responsivity scales realised using three different techniques. The third work package looks at the ageing of materials and components under intense UV irradiation and then applies the results to improving the measurement of intense UV radiation. The last technical work package applies developments from work packages one and two to improve the calibration of solar UV radiometers. The final work package is for management to ensure proper co-ordination.

Work package 1: Filter radiometers

Introduction

The development of cryogenic radiometry has led to an order of magnitude improvement in the accuracy of detector scales in the last decade. In order to extend this improvement in accuracy to the measurement of sources that have a broad spectral emission profile, detectors are required that can measure a specific narrow spectral band and that can be calibrated against a cryogenic radiometer. In practice the narrow band spectral response is achieved by placing an optical filter in front of a detector that has a much wider spectral response. This work package covers the development of filter radiometers for the measurement of spectral irradiance of ultraviolet sources. Two different types of filter radiometer were initially designed, the first using trap detectors and the second using solar blind photodiodes.

Trap detectors are commonly used throughout the visible and near infra red as spectral responsivity transfer standards. Trap detectors have a low reflectance and hence the spectral responsivity of a complete trap based filter radiometer can be assessed by measuring the spectral characteristics of the filter and the trap separately. The trap detector has a limited field of view and much higher response in the visible and near infrared than in the ultraviolet and the difficulties that this may cause in their use is being investigated as part of this work package.

High quality wide band gap, solar blind photodiodes have only recently become available. Materials such as Silicon Carbide, GaN and Diamond can be used to construct large area, stable photodiodes that have no response at wavelengths longer than typically 400 nm. This means that they do not require rigorous blocking of longer wavelength radiation unlike filter radiometers based on silicon photodiodes. During the formulation of the project several manufacturers claimed availability for large area devices based on the materials listed above. Unfortunately, availability evaporated once firm quotations and delivery dates were requested or the cost escalated to US$50,000 for single samples. The best available technology was GaAsP detectors which have a response up to around 650 nm and these were selected for use in the wide band gap filter radiometers.

The construction of filters stable to variations in environment (e.g. humidity) and ultraviolet irradiance has advanced considerably during the past five years and much progress has been reported in both the technical journals and in manufacturers literature. A specification for the design of the filters was formulated by NPL based on many years experience of interference filters in the visible and infra-red. Especially important in the filter design is the specification of the blocking of long wavelength radiation. Production of the filters proved to be very difficult. Only one manufacturer eventually quoted for all wavelengths requested. Once ordered the construction and delivery of the filters took four times as long as originally estimated.

This was mainly due to the need for more than one attempt before specification was met.

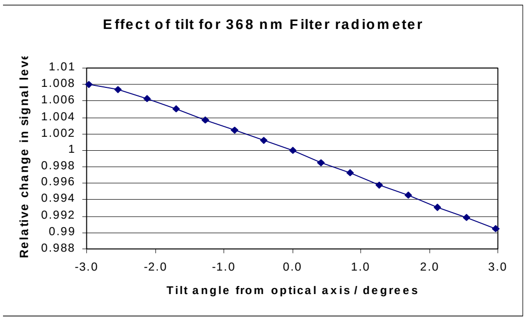


Figure 1. Typical change in recorded signal as filter radiometer is misaligned.

Results

Three trap based and three GaAsP based filter radiometers at each of centre wavelengths of 248 nm, 313 nm, 330 nm and 368 nm were constructed and calibrated at HUT, NPL and BNM-INM. The measurement sequence for all the filter radiometers, apart from the 248 nm filter radiometers, was for all filter radiometers to be first measured at HUT. Then one of each type and wavelength was kept at HUT as a control and the rest circulated to NPL and BNM-INM for characterisation before being returned to HUT to be re-measured. The 248 nm filter radiometers were calibrated and measured at NPL and BNM-INM only. Tests on other characteristics of the filter radiometers such as out of band blocking, effect of misalignment and temperature dependence were performed at NPL. A typical variation in signal level with the angle of tilt from the optical axis is shown in Fig. 1.

After the filter radiometers were returned to HUT and re-calibrated, measurements of the transmission of the filters from the trap based filter radiometers showed changes of between +0,5% and +1,5% in transmittance with little difference between the control and the distributed filter radiometers. Figure 2 illustrates the problem.

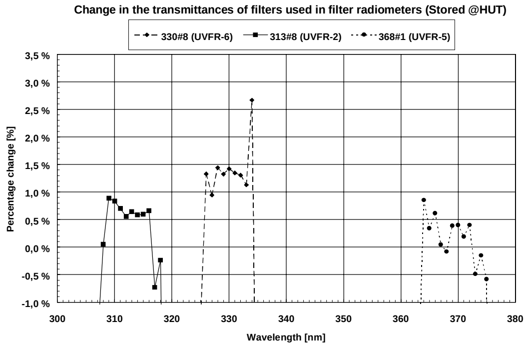


Figure 2. Typical changes in the filter transmittances. Transmission increased in all filters during the one-year period.

The results of the filter radiometer measurements show that HUT and NPL are in agreement within uncertainties for all wavelengths and detector types. BNM-INM is also in close agreement for the GaAsP based filter radiometers but the trap-based filter radiometer results are significantly different. The cause of these discrepancies is still being investigated. Typical results are shown in Fig. 3. Examination of Fig. 3 clearly shows the difference between calibration using very narrow bandwidth laser lines (as at NPL) and using monochromator based methods with finite bandwidths. For the monochromator method in particular it is clear that a very accurate and reproducible wavelength scale is required particularly when measuring the sharp sides of the spectral responsivity profile.

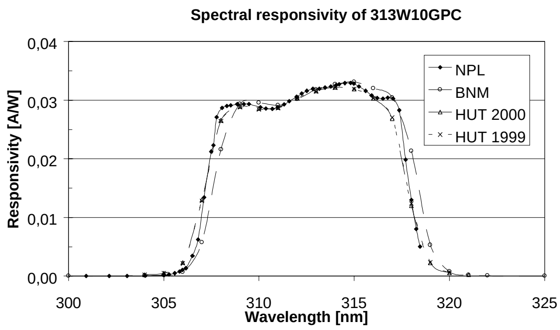


Figure 3. Typical UV filter radiometer calibrations by HUT, NPL and BNM-INM.

Work package 2: Comparison of techniques to establish high accuracy ultraviolet radiometric scales

The objective of this work package is to compare different measurement techniques for the establishment of a continuous high accuracy ultraviolet spectral responsivity scale traceable directly to a cryogenic radiometer. The target uncertainty for the scale is 0,1 % to 0,3 % from 200 nm to 400 nm. The three techniques that are being used involve the coupling of three different sources of UV radiation to cryogenic radiometers. These sources are laser radiation, synchrotron radiation, and radiation from a monochromator based source.

The establishment of a spectral responsivity scale requires reliable standard detectors on which to hold the scale irrespective of the method used to derive the scale. Ultraviolet degradation effects have been reported for some types of detectors. Selection of suitable detectors was therefore of paramount importance as any ageing effects due to ultraviolet radiation will limit the attainable accuracy of the spectral responsivity scale. The availability of several new detector types with improved performance in the ultraviolet indicated that improvements in the detector spectral responsivity scale in the ultraviolet could be achieved. Tests on different detector types identified one type of detector, a PtSi passivated photodiode, that was highly stable to UV irradiation and also had good uniformity. Trap detectors and single element transfer standards were constructed out of these devices for use in the realisation of UV spectral responsivity scales.

Currently, the synchrotron and laser based scales have been realised on the detectors and work on the monochromator based scale is underway.

Work package 3: Improving industrial measurements

Introduction

The objective of this work package is to deliver improved ultraviolet scales and measurement practice to industrial users of ultraviolet radiation. Two particular applications are being targeted, semiconductor lithography and non-destructive testing. This work package includes the development of an industrial intense UV irradiance meter that is stable to better than 2 % after prolonged exposure to intense UV irradiation. The other activity in this work package involves using the filter radiometers constructed and tested in work package 1 for the measurement of UV sources used in non-destructive testing.

Degradation of most optical components and detectors is a significant hurdle that must be overcome before any successful ultraviolet irradiance meter can be designed that can remain accurate to better than 2 % after prolonged exposure to ultraviolet irradiance levels of up to 500 mW cm^{-2}. The first part of this work package was designed to select and test optical components for stability when exposed to high ultraviolet flux levels so as to establish the most suitable materials and components to construct stable, intense ultraviolet irradiance meters at wavelengths of 193 nm and 248 nm. The requirement for an accurate, stable, intense UV irradiance meter was identified as key to the user community, since commercially available devices have been found to give variations in recorded signal levels between meters of over 30 %, even from the same manufacturer when ‘calibration uncertainty’ is quoted at around the 1 % level.

Results

Although much work has previously been performed on irradiation of materials with UV a large proportion of the data is proprietary and the relatively sparse data in the literature is often of poor quality or of limited range. Therefore, a significant amount of work was performed in identifying and testing a wide range of materials and devices. These include many samples of fused silica of different grades and from different sources, CaF_2, laser beam splitters, thermopile detectors, sphere diffusers and other attenuators. The measurement procedure was to characterise the samples before and after irradiation. Samples were either irradiated using an all lines Mercury source at 50 mW cm^{-2} or using excimer laser at 193 nm delivering a total accumulated energy of 1100 J cm^{-2} at peak powers of over 1 MW cm^{-2} A typical ageing change is shown in Fig. 4 for excimer irradiation. The results obtained are not encouraging with all materials showing degradation after exposure to UV.

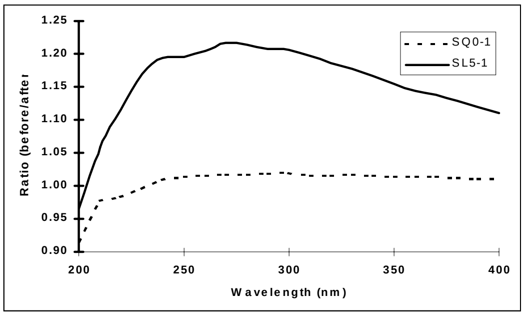


Figure 4. Typical changes seen in diffuse transmittance of two different grades of fused silica after irradiation with excimer laser radiation at 193 nm.

One of the main criteria when selecting components for testing was the need to attenuate the UV radiation levels falling on the detector. An alternative approach to utilise a detector with a very low spectral responsivity was rejected because of the need to be able to calibrate the detector against existing spectral responsivity scales using facilities in existence at national measurement institutes. Such facilities typically use monochromator based sources which deliver power levels of up to around 100 µW in the UV compared to peak powers of up to 100 MW from excimer laser sources used in semiconductor lithography. Spanning the many orders of magnitude between calibration and industrial sources places huge demands on any calibration facility and cannot at present deliver the accuracy required. The preferred approach is to develop an attenuator to place before the detector. Calibration of the attenuator is itself a significant challenge. Currently, possible avenues towards the goal of construction and calibration of an intense UV irradiance meter are being pursued.

Work package 4: Demonstration of improved calibration techniques for solar radiometers

Improving the calibration of solar radiometers was chosen as a demonstration application since there is a real need to improve the calibration of spectroradiometers used to measure solar ultraviolet radiation. Calibration of e.g. Brewer spectroradiometers is problematic, because their transportation to calibration laboratories may affect their calibration, and calibration outside in the measurement sites is influenced by environmental conditions. To enable field calibrations of various spectroradiometers, a portable calibration system for solar UV monitoring instrumentation is being developed. The calibration of this device is maintained using the filter radiometers constructed under work package 1.

Figure 5. A photograph of the first prototype calibrator with the associated electronics for lamp control and the monitoring filter radiometers.

The construction of the first prototype calibrator can be seen in Fig. 5. The calibrator utilises a 1 kW DXW lamp as the light source. The output of the light source is continuously monitored with two temperature-controlled filter radiometers at 313 nm and 368 nm wavelengths. The measurement distance of 50 cm can easily be adjusted by using unique interchangeable adapter plates for each spectroradiometer to be calibrated.

A significant part of the work has been assigned for measuring the ageing properties of DXW and FEL lamps. 12 specimens of each type where burned for 80 hours in simulated using conditions, and their spectral irradiances, currents and voltages where monitored. Based on the measurement results, DXW lamps where chosen. The lamp is operated in current-stabilised mode. When the ageing characteristics of the lamp are known, the signals of the monitoring filter radiometers can be used to calculate corrections for the spectrum as the lamp ages.

The preliminary measurements are encouraging. The device works satisfactorily in both laboratory and in field. Based on the experience gained, a second improved prototype calibrator will be built by summer 2001.

Summary of the 3rd International Workshop on Detector-Based UV Radiometry

H. Rabus
PTB, Berlin, Germany

The 3rd International Workshop on Detector-Based UV Radiometry was organised as a satellite meeting of the 4th UV Thematic Network Workshop at SP and took place on September 6, 2000.

The first session was devoted to the Agreed Euromet Project 437 "Evaluation of the radiometric performance of UV photo-detectors." The project co-ordinator presented a summary of the motivation of the project, the activities that took place, and the results that were obtained, which indicate agreement of the UV spectral responsivity scales of NPL, PTB and NMi-VSL within the combined standard uncertainties. In the case of the comparison between NMi-VSL and PTB, the recalibration at PTB produced strange results for one of the two employed photodiodes, which may be due to a damage caused by handling of the diode. In order to clarify this situation, the co-ordinator suggested to continue the project until a second recalibration of the two photodiodes by PTB took place and the photodiodes used in the comparison with NPL, which are currently circulated within the EU-SMT project [1] have been returned to PTB and recalibrated. In the discussion following the presentation, this proposal was generally approved and extended such that the photodiodes should also be sent to NIST for calibration and then be recalibrated again by PTB. The target date for completion was set to be early 2001, such that a publication of the results in Metrologia would not interfere with the upcoming CCPR Key comparison of UV spectral responsivity. A brief account of the results available at the time of the workshop was decided to be included in the report of the working group 2 of the Thematic Network [2].

The second session dealt with the technical protocol of the CCPR Key comparison of UV spectral responsivity. A brief account of the rules and the proposed timetable set in the draft protocol, and of the status of the preparation of the comparison at the pilot laboratory, was given. The following discussion by the workshop participants revealed some points to be added to the protocol. Moreover, there was general agreement that the ambitious tight time schedule should be kept as is.

In the third session, Toomas Kübarsepp (HUT) gave an interesting talk on "Modelling the spectral responsivity of silicon-based photodetectors in the UV", which addressed the issues of modelling the quantum yield of silicon in the UV and of the spectral responsivity of PtSi/n-Si Schottky photodiodes. As for the first point, the model reproduced the average of experimental data for the quantum yield of silicon from three different sources within a relative standard deviation of 0,3 %. However, the data sets showed excellent agreement at wavelengths down to 260 nm but significant discrepancies at shorter wavelengths. The discrepancies increased with decreasing wavelength. This result caused some confusion during the discussion following the talk, because the

The author is with
Physikalisch-Technische Bundesanstalt
Abbestraße 2-12
DE-10587 Berlin
Germany

Telephone: +49-30-82004-236
Telefax: +49-30-82004238
E-mail: hans.rabus@ptb.de

spectral responsivity scales of the NMIs that provided the data were reported in the first session to be in agreement. The generally consented outcome of the discussion was that auxiliary quantities that are not accessible to direct measurement, such as "the" quantum yield of silicon, should not be taken too seriously. The important aspect of the presented approach was the successful interpolation of the spectral responsivity by a physically motivated model. The model that was developed for the PtSi/n-Si Schottky photodiodes allowed to reproduce the spectral responsivity within a standard deviation of 2,3 %. The deviations showed a clear oscillatory structure that was attributed to a quantum well which had to be included in the model to cure a drastic mismatch in the vicinity of the X4→X1 transition around 295 nm.

The last session of the workshop was meant to give an overview of status and recent developments in detector-based UV radiometry:

- Ping-Shine Shaw gave an overview of the UV radiometry facilities of NIST at their SURF III electron storage ring, then presented the recently achieved improvement that was accomplished in the 130 nm to 320 nm spectral responsivity scale by the use of the cryogenic radiometer ACR with synchrotron radiation, and finally showed very informative results of detector damage studies under exposure to 157 nm laser radiation.

- Nigel Fox reported on the current calibration route of the NPL UV spectral responsivity scale, which is based on measurements with the cryogenic radiometer at two UV laser wavelengths and an interpolation using a pyroelectric detector at a monochromator facility. He gave a detailed discussion on the uncertainty budget, demonstrating how the low "base" uncertainties of 0,2 % (k=2) may be deteriorated to values up to 1 % if the detector has an unfavourable spectral shape.

- Charles Schrama described the facility used at NMi-VSL for the realisation of the spectral responsivity scale based on a cryogenic radiometer operated with spectrally dispersed radiation from a xenon arc or a quartz tungsten-halogen lamp. He also showed that the NMi-VSL spectral responsivity scale maintained on silicon p-n trap detectors was stable to better than 0,6 % over one year.

- Hans Rabus briefly reviewed the latest realisation of the PTB scale for which a cryogenic radiometer operated with spectrally dispersed synchrotron radiation is used for the interpolation of measurements at a laser-based system.

The workshop was concluded with a plenary discussion that focussed on the question whether the series of workshops would go on after the end of the Euromet project. The general opinion was that these meetings on detector-based UV radiometry should in fact be continued, at least in the form of informal satellite meetings to other events. Ping-Shine Shaw announced that NIST as the host of next year's NEWRAD conference has already a plan to have such a satellite meeting, and the planned 5th workshop of the Thematic Network in 2002 would definitely also be a suitable opportunity.

[1] Neil Harrison, "Improving the Accuracy of Ultraviolet Radiation Measurement," *UVNews* **5**, 18 (2000).

[2] Report of WG 2 of the UV Thematic Network by Jürgen Metzdorf *et al.* (to appear in *UVNews* **6**)

Assessing UV Hazards Using Portable Measuring Instruments

Andrew Ridyard
4D Controls Ltd/ Solatell, UK

1. Introduction

In space, there is plenty of high energy radiation from the Sun. Our atmosphere does a good job of protecting us from the most harmful, short wavelength radiation down into the UVC and further down into the X-ray region. Human skin has evolved to protect us from the harmful effects of UV radiation that is left at the surface of the Earth. Life forms in general have evolved in an environment containing no short wavelength UVC radiation, therefore, DNA, the building block of life, has a strong absorption of UVC. A reasonable explanation is that natural selection favored the chemical composition of *prototype DNA* which was resistant to radiation found naturally at the surface of our planet aeons ago, and did not need to evolve to resist what was not present naturally, i.e. short wavelength UVB and UVC radiation.

Many experiments involving different human beings have demonstrated a strong wavelength dependent UV sensitivity to our skin. This has been formalised as the so called *Erythemal Action Spectrum* as shown in Fig. 1 [1] - the effect being easily observed reddening (Erythemal) of the skin. This should not be confused with any other physiological effects caused by UV - such as of skin cancer - which are generally harder to obtain data on.

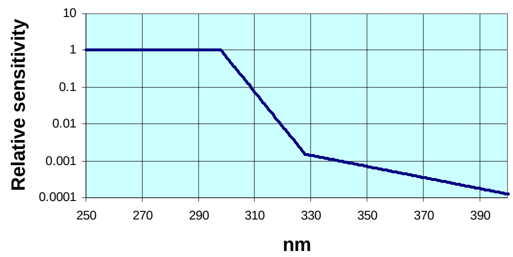


Figure 1. Erythemal action spectrum for skin (CIE:1995). [1]

Most fair skinned people are aware of the effects a good dose of UV radiation from the sun can cause. But how do we assess in a more scientific way the dangers of a light source, which exposes us to possibly harmful levels of UV radiation? The question is even more important if the light source contains an *unnatural* level of short wavelength radiation

2. UV light sources

2.1. Types

Apart from our Sun as a source of UV, which has a rapidly diminishing power with reducing wavelength (down to effectively zero below 300 nm), there are an increasing number of artificial sources of UV radiation used in everyday life. These can be broadly classified into the following categories:

- Continuous spectra e.g. from Quartz Tungsten Halogen (QTH), and Xenon lamps,
- Line spectra, e.g. from low, medium and high pressure Mercury vapor lamps used in industrial and germicidal applications, sometimes with special additives in the bulb fill,
- Broad spectra, e.g. from tanning lamps and medical use treatment lamps,

The author is with
4D Controls Ltd/Solatell
Unit 8, Pool Estate, Redruth
Cornwall, TR15 3RH
UK

Telephone: +44-1209-214400
Telefax: +44-1209-314415
E-mail: andrew-r@solatell.com
http://www.solatell.com/

generally characterised by a broad continuum with characteristic mercury vapour lines superimposed on top.

This last category, can then be routinely subdivided into types of lamp by means of their effective irradiance, taking into account the Erythemal Action Spectra of Fig. 1, according to an internationally recognised table of lamps types [1], as shown in table 1.

Table 1. Classification of lamps. [1]

Type	$Ueff_{<320}$ (250-320 nm) [W/m^2]	$Ueff_{>320}$ (320-400 nm) [W/m^2]	Description
I	<0,0005	≥ 0.15	UVA lamp
II	0,0005 - 0,15	≥ 0.15	UVA +some UVB
III	< 0,15	< 0.15	UVA + UVB lamp
IV	≥ 0,15	< 0.15	Strong UVB lamp

2.2 *Hazards*

Each category of artificial lamp can therefore have it's effect on the human skin, determined if one can contrive an instrument to firstly, scan the spectrum of the light source from 250 to 400 nm with reasonable accuracy with known absolute uncertainty levels, and secondly, to be able to multiply the spectral distribution by the Erythemal Action Spectra. Any other *action* (or absorption) spectra can also be envisaged, and these do exist (e.g. in the USA that developed by the ACGIH and recommended by the NIOSH).

Once the necessary calculation has taken place, one can consider the degree of a potential hazard represented by the light source (at the distance it is being measured) by simply considering the effective irradiance. The light source can also be classified according to table, since Ref. [1] requires that *UV appliances shall not emit radiation in hazardous amounts and their effective irradiance shall comply with values specified* [*in Table 1*].

In addition to classifying lamps, such an instrument can also assess how long human beings can be safely exposed to UV radiation. An exposure to UV power of a certain intensity and spectral distribution, for a certain amount of time results in a *UV dose*. The so-called *Standard Eryhthema Dose* (SED) has been proposed [2] and later ratified by the CIE, where 1 SED is equivalent to an Erythemal effective radiant exposure of 100 J/m^2 , or 100 W·s/m^2, and the Erythemal Action Spectra (Fig. 1) is used to weight spectral irradiant data.

3 Measurements methods

3.1 *Radiometers*

Radiometers are the most common type of device used in light measurement. In the measurement of UV, the radiometer will invariably comprise a special, wavelength dependant, band-pass optical filter followed by a photodiode, or other photoelectric transducer. As such, the device is able to discriminate between pass band and out of band radiation, but is not able to actually determine wavelength.

Radiometers are therefore not at all well suited for measurement of UV lamps to assess the potential hazard they represent. Furthermore, they can only give reasonably accurate readings for the type of lamp against which they were calibrated; if the lamp spectrum is substantially different from the calibrating lamp then the readings given are in arbitrary, uncalibrated units.

3.1.1 Soft Filtering

The *special filter* in the radiometer has a transmission property, which is carefully selected during the design process. This filter characteristic will tend to always have a soft roll off either side of the pass band. Many ingenious ways have been thought of to try to follow the Erythemal Action

Spectra of Fig. 1. However, when it comes to separating out wavelength contributions below and above the 320 nm dividing line in Table 1 it becomes impossible not to suffer from the inevitable *crosstalk* between the skirts of two adjacent optical filters (i.e. a UVA and a UVB filter). Added to this, is the wavelength dependant sensitivity of the photodiode - generally this sensitivity falls with reducing wavelength. In a perfect silicon diode with 100 % quantum efficiency (and with no wavelength dependant surface absorption and re-emission effects) this effect is due simply to the fact that a photon at 200 nm has twice the energy as that of a photon at 400 nm. Each photon generates one electron in the perfect photodiode, so there is half the electron current to be sensed at 200 nm compared to 400 nm at the same power. In fact a real photodiode does not have close to a linear increase in response with wavelength over a relatively large range such as the 250 to 400 nm range we are interested in.

The combined effect of the manufacturing spread of the soft filter characteristics and the spread and non-linearity of the photodiode response results in a wavelength dependant sensitivity which is very device dependant, and may also change with time, temperature and other environmental factors effecting primarily the filter's stability.

3.1.2. Blocking

Another aspect of the radiometer is that it must effectively block out-of-band radiation so that, even if this radiation is several orders of magnitude greater than in the band of interest, its effect should be removed as completely as possible. For instance, the visible content of terrestrial solar radiation is many orders of magnitude greater than that in the UV region below 320 nm. The broad band UVB filter must block by a factor of many orders of magnitude any visible radiation. This is a severe requirement for a broad band UVB filter, but even more severe for an UVA filter which ostensibly should stop at 400 nm, and should block all wavelength above, in the visible region.

3.2. Spectroradiometers

In fact, to comply with the prescribed standards for assessing hazards, Ref. [1] requires that *The measuring instrument used measures the mean irradiance over a circular area having a diameter not exceeding 20 mm. The response of the instrument is proportional to the cosine of the angle between incident radiation and the normal to the circular area. The spectral distribution is measured as intervals of 1 nm by means of a spectrophotometer having a bandwidth not exceeding 2,5 nm*. Here, for spectrophotometer read spectroradiometer, but otherwise this is a complete and concise description of the required instrument.

The spectroradiometer developed comprises the following optical elements:

- Diffuser or other *cosine response* light collecting optics,
- Entrance slit,
- Focussing mirror,
- Diffraction grating,
- Self-scanned multi-element photodiode array.

The spectroradiometer is designed so that the light to be analysed enters, is split up into a UV spectrum, and focussed on the photodiode array. Each element of the photodiode array corresponds to a unique wavelength in the UV spectrum. The bandwidth of spectroradiometer is defined by the entrance slit and the spacing of the photodiodes in the array. Each element responds to photons landing on it in proportion to the intensity in that narrow bandwidth of entrance light. Such an instrument can be accurately and permanently calibrated; the calibration of the instrument is described in the following section.

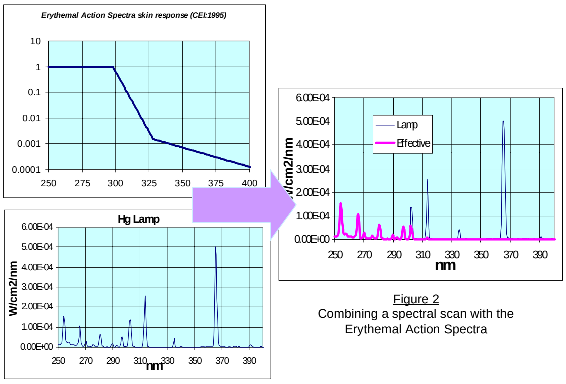


Figure 2. Combining a spectral scan with the Erythemal Action Spectra.

An example of how, in this case, an industrial mercury arc lamp spectral scan can be mathematically convoluted with the Erythemal Action Spectra is shown in Fig. 2. Such a spectroradiometer has been constructed in a convenient small hand held portable form, by the author, based on a patented optical design for a miniature monolithic single grating spectrograph [3]. The instrument is referred to as the *Sola-Hazard*.

3.2.1. Hard filtering

Another aspect of the spectroradiometer, being able to split UV light into a spectrum, is that only the exact part or parts of the spectrum of interest can be taken into consideration. By summing the power ordinates over a certain wavelength range from the resultant spectral scan, a truly square, *hard* filter characteristic can be obtained, as opposed to the *soft* roll off characteristics of the radiometers mentioned in the previous section.

4. Calibration

The Sola-Hazard instrument described above, must be calibrated in order to make measurements of a variety of UV light sources, with reasonable accuracy and acceptable uncertainty levels.

By working with the National Physical Laboratory (NPL) in the UK, 4D Controls/ Solatell have formalised a calibration method for the instrument, for which they provide standard sensors and light sources. The standard stages of calibration also recommended in *Reliable spectroradiometry* [4] are:

1. Define light collection geometry - generally using cosine response approximating diffuser,

2. Wavelength calibration - using a low pressure mercury lamp for the benefit of its very precisely defined spectral lines positions,

3. System characteristics (response shape) calibration - using a Deuterium lamp, with a smooth continuum from 250 to 400nm,

4. Overall, absolute intensity calibration - using a *facial solarium* which conveniently has output down to around 296 nm with vestigial evidence of the mercury line in this region, which is useful for assessing stray light performance.

In fact, the stray light performance level of the spectroradiometer is thoroughly characterised during the calibration procedure. This is done by software to allow further reduction in stray light during UV source measurement. Generally the monolithic spectrographs have a very even level of stray light across the array, and therefore compensation can be made for this unwanted signal by measuring stray light and subtracting it from the *real* signal.

5. Conclusions

A small (196×100×38 mm), low cost, simple to use, battery operated, hand held, single grating spectroradiometer has been manufactured to allow spectra scans to be taken of solarium lamps and other UV light sources in a convenient way. The spectral scan obtained is multiplied with the Erythemal Action Spectra in software to obtain an effective irradiance in the ranges 250-320 nm and 320-400 nm. The lamp can then be classified according to International standards. The instrument can also measure hazards represented by the light source in accordance with the internationally recognised Standard Erythemal Dose units. By independent assessment, the error levels of the instrument have been shown to be reasonable when compared to a double grating instrument costing many times more. Stray light levels have been identified as the largest source of error. Much work has been done and progress continues to be made to improve the instrument's performance.

6. References

[1] EN60335-2-27: *Safety of household and similar appliances*, Part 2: "Particular requirements for appliances for skin exposure to ultraviolet and infrared radiation" (1997).

[2] CIE, *Draft Standard CIE DS 007.1E. Standard Erythema Dose* (1996).

[3] *International patent WO 96/05487* published under the patent co-operation treaty (PCT) Radiation Detector: inventors - A.W.Ridyard and D.D. Shrewsbury.

[4] Henry J. Kostkowski, *Reliable spectroradiometry*, ISBN 0-9657713-0-X (1997).

Andrew Ridyard, the author of this article, is managing and technical director of 4D Controls Ltd. 4D Controls design, develop and manufacture a range of UV measurement, control and automation products. Andrew is a Chartered Engineer and a Fellow of the Institution of Electrical Engineers. He is the inventor of the patented Solatell® technology for UV radiation spectral distribution measurements and chief designer of UV spectral instrumentation for 4D Controls Ltd. He has presented numerous conference papers in the UK, Europe, the USA and Japan.

Report on the Second Training Course on Ultraviolet Measurement

Bill Hartree
NPL, UK

The second Training Course on UV Measurement was held at the Alpotel, Innsbruck, Austria on May 4-5, 2000. It was organised by the National Physical Laboratory (NPL) with assistance from Innsbruck University.

Only seven people attended the course, a very poor attendance and far lower than the number attending the first run. There are probably several reasons for this. First, wider publicity would certainly have helped. Whereas NPL has had success in recruiting participants from the UK for its own courses over many years mechanisms are not yet in place for doing this at a pan-European level. Future organisers of such courses should bear in mind the need for adequate resourcing of publicity activities. A second reason may well be cost. Such international courses are inevitably expensive to organise, and this was reflected in the registration fee of €600, which was a significant barrier to participation for some organisations, judging from feedback received. Travel costs were also prohibitively high for many people. Third, the EU’s political and cultural boycott of Austria was imposed during the run up to the course, and may well have discouraged people from attending.

The course was essentially a re-run of a course held at the NPL in 1999. It consisted of a series of twelve lectures spread over two days. The broad content of the course had been determined to a considerable extent during discussions at the First Workshop of the EU Thematic Network in Helsinki in 1998, while the content of individual lectures was decided by each speaker, with guidance from NPL. The first lectures covered the basics of measurement: concepts, definitions, detectors, sources, materials, broad band and spectrally resolved measurements, the treatment of uncertainty in measurement, and traceability and quality assurance. There was then a series of lectures on particular application areas: Solar UV, Health, High power measurement, and finally a lecture on new developments. Some modifications to the original course were made for Innsbruck, following comments made at the NPL meeting. In particular the course content was modified to avoid the duplication of material that had occurred in the first course. Also the subject of UV spectrophotometry was included.

The course was very well received by the few people who did attend. All returned Course Evaluation Forms, which indicated a consistently high level of satisfaction with the course content, presentation, organisation and usefulness. Indeed the Innsbruck course received higher ratings than the NPL course, indicating that the changes to the course content were indeed beneficial.

Since this is the final such course to be held under the Thematic Network, consideration has been given to the future of the course. It seems unlikely that the course can continue

The author is with
National Physical Laboratory,
Queens Rd, Teddington,
Middlesex, TW11 0LW
UK

Telephone: +44 (0)20 8943 6416
Teleax: +44 (0)20 8614 0411
E-mail: bill.hartree@npl.co.uk

without the support of the European Commission, at least in its present form. In the absence of future runs of the course it has been agreed by the Network to make the course notes publicly available, subject to the authors' permission. The price charged for the notes would only be such as to cover any copying and binding costs. Participants at both courses have suggested that these notes could provide a valuable resource for future courses, in particular those aimed at more specialist audiences, for instance hospital technicians, and perhaps organised at a national rather than European level.

Finally, big thanks are due to the local organiser, Professor Mario Blumthaler, and to the Alpotel for their warm hospitality: in particular the quality and amounts of food and drink greatly enriched the event!

Working Groups

The Network has four working groups, each working on a selected key issue in UV measurements. The working groups are operating mainly by exchanging E-mail. If you wish to be informed about their activities, please contact the corresponding working group leader. You may also use the service card at the end of this *UVNEWS*.

Working group 1: Guidance for UV power meter classification for particular applications

Gigahertz-Optik
Director Anton Gugg-Helminger
Fischerstraße 4
D-82178 Puchheim, Germany

☎ +49-89-89015920
Fax: +49-89-89015950
✉ a.gugg-helminger@go-puchheim.de

Working group 2: Improvement of measurement and calibration methods for spectrally resolved UV measurements

Physikalisch-Technische Bundesanstalt
Department 4.1 Light and Radiation
Prof. Dr. Jürgen Metzdorf
Bundesallee 100
D-38116 Braunschweig, Germany

☎ +49-531-5924100
Fax: +49-531-5924105
✉ Juergen.Metzdorf@ptb.de

Working group 3: Improvement of measurement and calibration methods for spectrally weighted UV measurements

NPL Management LTD
National Physical Laboratory
Dr. Nigel Fox
Queens Road, Teddington
Middlesex, TW11 OLW, United Kingdom

☎ +44-181-9436825
Fax: +44-181-9436935
✉ nigel.fox@npl.co.uk

Working group 4: UV Measurements related to health and safety

University of Dundee
The Photobiology Unit
Dr. Harry Moseley
Ninewells Hospital & Medical School
DDI 9S4, United Kingdom

☎ +44-1382-632240 / +44-1382-633894
Fax: +44-1382-646047
✉ H.Moseley@dundee.ac.u

More information, including the latest annual reports, can be found at the Internet pages of the working groups

(http://metrology.hut.fi/uvnet/groups.html).

If you would like to add some material to the web pages of your working group, please consult the corresponding working group leader.

News-Flash

Radiometer/Photometer System Performs Visible and Radiometric Measurement

A versatile radiometer/ photometer system that includes an optical bench post, detectors, diffusers, and filters for quantifying a wide range of measurements in specific light units is available from ABLE Instruments and Controls Ltd.

The IL1715 Research Radiometer/ Photometer System includes the IL1700 instrument, an SED033 detector, *Y* photopic filter, *F* flat response filter, *W* diffuser, an optical bench post, and carrying case. ABLE have designed the system to eliminate the separate instruments and detectors typically required for making both visible and radiometric measurements. Furthermore system readings are flexible and may be viewed as watts/cm^2, ft-candles, or lux.

Featuring automatic zeroing and automatic ranging during exposure integrations over an 8,5 decade range above nW/cm^2 and 5 milli-lux, the IL1715 has a photometric dynamic range of $5 \cdot 10^{-4}$ to $1 \cdot 10^{6}$ lux and a radiometric dynamic range of $1 \cdot 10^{-9}$ to $2 \cdot 10^{-1}$ W/cm^2. Consequently ABLE's new research radiometer/photometer system is suitable for a wide variety of flash and continuous wave light measurements.

Pricing for the IL1715 Research Radiometer/ Photometer System or any of ABLE's range of radiometers, photometers and spectroradiometers is available by contacting ABLE directly.

Further information:
ABLE Instruments & Controls Ltd
Cutbush Park, Danehill
Lower Earley, Reading
Berkshire, RG6 4UT
UK

Telephone: +44 (0) 118 931 1188
Telefax: +44 (0) 118 931 2161
E-mail: marketing@able.co.uk
http://www.able.co.uk/

European Network for Arctic-Alpine Multidisciplinary Environmental Research ENVINET

Coordination and harmonisation of UV-related activities in a multidisciplinary framework

Jon Børre Ørbæk
Norwegian Polar Institute, Tromsø, Norway

ENVINET is a research infrastructure network funded for the next 3 years under the program "Improving Human Potential" - activity "Access to Reseach Infrastructures" of the European Communities. The network focus on multidisciplinary environmental research and involves representatives from 18 environmental research infrastructures from the European Alps to the Arctic, representatives of their users and representatives from relevant international organisations and networks. The participating infrastructures cover a broad range of environmental sciences primarily within:

- Atmospheric physics and chemistry,
- Marine and terrestrial biology.

ENVINET is put together for the main purpose of fostering new cross-discipline and cross-infrastructure collaboration of environmental research activities in Europe. Joint scientific and technical studies are generated under the network in the crossing fields of environmental sciences under Climate Change, Ozone and UV-radiation, Long Range Transport of Pollutants and Biodiversity.

Working groups are established for the purpose of improving the quality of the research by elaborating and exchanging information related to the improvement of data sets, analyses tools, data processing methods, measurement protocols and comparability, quality assurance, instrument inter-comparison and networking, and needs for complementary and cross-disciplinary activities.

The network will organise 4 general meetings during the 3 year contract. The first meeting was held in Ny-Ålesund during 22 - 26 June 2000. The next will be held in the Alps during 1 - 4 April 2001. The meetings and activities will be open (to some extent) for possible new participants from other stations or organisations. Exchange of information is through email and fax, newsletters and Internet at http://www.npolar.no/envinet.

Further information:
Jon Børre Ørbæk
Atmospheric Sciences, Polar Climate Group
Norwegian Polar Institute, Polar Environmental Centre
N-9296 Tromsø
Norway

Telephone: +47 77 75 05 56 (05 00)
Telefax: +47 77 75 05 01
Email: jonbo@npolar.no
http://www.npolar.no/envinet

Large Scale Environmental Research and Monitoring facilities in the European Arctic
Opportunities for physical and biological UV-research at the Ny-Ålesund Large Scale Facility

Jon Børre Ørbæk
Norwegian Polar Institute, Tromsø, Norway

The Ny-Ålesund International Arctic Environmental Research Station is situated in Ny-Ålesund, Svalbard, Norway. Under the "Access to Research Infrastructures" activity of the "Improving Human Potential" programme of the European Community 5th framework program, access is provided for new European scientists to perform environmental research at the Ny-Ålesund research facilities. Interested European research groups and scientists are invited to submit scientific research proposals on Arctic environmental research within:

- Marine and Terrestrial biology
- Climate Research in the troposphere and stratosphere
- Radiation budget, UV-radiation and Ozone
- Surface phenomena, snow and ice
- Air quality research and arctic pollution
- Space geodesy

Several monitoring programs and biological investigation campaigns are well established in Ny-Ålesund in the field of UV-radiation and biological effect studies. The monitoring programs include a number of weighting, filtered and spectral resolved instruments in the UVB and UVA region, and biological investigation have been performed both in terrestrial, marine and limnic communities. New projects are invited in all fields with complementary value to existing activities. Next deadline for proposals will be early spring 2001, posted on the Ny-Ålesund home page at http://www.npolar.no/nyaa-lsf as well as through announcements in Nature.

The Norwegian Polar Institute is the co-ordinator of the Ny-Ålesund LSF, which is a run as a consortium by the Norwegian Polar Institute (NP), the Alfred Wegener Institute for Polar and Marine Research (AWI), the Norwegian Mapping Authority (NMA), the Norwegian Institute for Air Research (NILU), the Natural Environment Research Council (NERC) and the Kings Bay Company (KB). Access is offered under this program for research groups form Member States and Associated States of the European Union. Subject to a scientific evaluation procedure, the selected projects are offered access free of charge to the research facilities which includes all infrastructural, logistical, technical and scientific support normally provided to external users. Grants are restricted to cover travel and subsistence costs for field campaigns or laboratory work for up to 2 months duration, or shorter visits involving the installation of well automated instruments for 3-12 months operation.

Further information:
Jon Børre Ørbæk
Atmospheric Sciences, Polar Climate Group
Norwegian Polar Institute, Polar Environmental Centre
N-9296 Tromsø
Norway

Telephone: +47 77 75 05 56 (05 00)
Telefax: +47 77 75 05 01
Email: jonbo@npolar.no
http://www.npolar.no/nyaa-lsf

NPL Optical Radiation Measurement Club
Medical Focused Interest Group Meeting

Safety issues in UV and blue light phototherapy

A J Coleman
Guy's & St Thomas' Hospital, London, UK

UMIST, 20/21st June 2000

The Medical Focused Interest Group (Medical FIG) met during the annual two day Optical Radiation Measurement (ORM) Club meeting that was held at UMIST. The Medical FIG attracted between fifteen and twenty delegates despite competition from the parallel sessions run by the UV Measurement and Colour Measurement FIGs. The main social event of the ORM meeting was a trip to Granada studios for a private tour and a good dinner. A large screen television was kindly provided in a separate room for the few unfortunate ORM delegates who elected to watch the England football team being ejected from the Euro 2000 competition by Romania.

Ray Lambe (*NPL*) chaired the Medical FIG round table discussion on a draft of the Best Practice Guide for UV Phototherapy Meter Specification. Meter specification is a topical issue with a large number of phototherapy centres using meters that are uncalibrated and poorly designed leading to the large observed dosimetry errors. The current draft document provides technical information on such issues as meter linearity, spectral matching, cosine correction, fatigue, temperature stability, out of band rejection, power supply, readout, and calibration. Discussion centred on the aim of the document and its target audience. It was decided to include a section describing best practice in terms more accessible to non-technical photherapy staff.

The main session of the Medical FIG covered safety and blue light phototherapy. *Stephanie Wentworth* (*CEDAR, Cardiff*), who has written the recent MDA report on the subject, gave a comprehensive overview:

Neonatal phototherapy

Blue light phototherapy is used to treat jaundice in the new-born caused by excess bilirubin. The effect of light on neonatal jaundice was observed in the late 1950s, and from exploring the effect of different wavelengths on bilirubin *in vitro,* blue light was found to be the most effective. This led to the development of blue light phototherapy devices. More recently some of the isomeric products of the photochemical reaction have been isolated bio-chemically and this along with consideration of skin optics has led to research into the effect of longer wavelengths of light on bilirubin.

Safety issues focus on the reduction of UV and IR components to insignificant levels. Eye protection for the neonates is essential if the light can shine in their eyes. Dehydration can also be a problem for neonates under phototherapy and must be carefully monitored.

Further information:
St Thomas' Hospital
Medical Physics
Dr. Andy J Coleman
Lambeth Wing
London SE1 7EH
UK

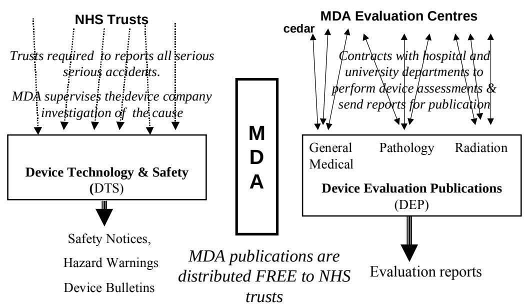
Telephone: +44-171-9228072
Telefax: +44-171-9228279
E-mail: andrew.coleman@gstt.sthames.nhs.uk

Commercial neonatal phototherapy devices use a variety of bulbs and fluorescent tubes and as a result the spectra vary widely; with all manufacturers claiming superior clinical effectiveness. However little independent clinical research work has been performed to establish the most clinically effective device for each patient group (e.g. Pre-term infants < 1kg or full-term babies). Similar to the position of ultraviolet phototherapy 20 years ago there is currently no agreed protocol for specifying a dose or administering blue light therapy. Other important considerations are parental and staff acceptance of the treatment device. In general, blue-light phototherapy can be used safely, with appropriate precautions, but the 'jury is still out' on optimisation

The discussion of safety aspects of blue light centred on the enormous variation in the absolute irradiance and relative spectral irradiance from different blue light sources. This can lead to metering problems. It was also disclosed that some lamps, if focused on the skin, can cause thermal damage. A recent study by Ostrowski, Pye and Laing on phototherapy hoods [*Acta Paediatr.* **89**, 1-4 (2000)] was cited as highlighting the possible hazard to the eye when blue lamps are positioned incorrectly.

Dianne Crawford (*CEDAR, Cardiff*) described the role of the Medical Devices Agency and the distinction between the Device Technology and Safety role and the Device Evaluation Publications. The diagram below was used by Dianne to summarise the different roles of the MDA.

Theoretical communications between the MDA & NHS staff



PLEASE HELP all the MDA funded Evaluation Centres **improve medical device assessment** by **sending information** about ALL accidents, incidents and near misses related to medical devices to: *cedar@uhw-tr.wales.nhs.uk* and we will forward them to the relevant Evaluation Centre.

The 'no-fault' reporting of adverse incidents and near misses has also been emphasised in recent NHS directives.

Don Burnham (*Able Instruments Ltd.*) presented a study carried out by Jim Lloyd (Newcastle) on the survey of UV meter calibration centres in the UK. A summary of results is presented below.

Initial Survey of UV Meter Calibration Centres

J.J. Lloyd
Regional Medical Physics Department,
Royal Victoria Infirmary,
Newcastle-upon-Tyne

Introduction

The importance of correct calibration of hand held UV meters is increasingly recognised in phototherapy. Regular re-calibration of meters is recommended but there is some concern that different calibration centres may give different results.

This survey was intended as an initial investigation of consistency between departments offering a calibration service. It should be stressed that no attempt was made to standardise methodology between centres prior to this survey. The survey is intended to give snapshot of the degree of variability that end-users (e.g. dermatologist) may experience in obtaining a meter calibration from difference centres.

Method

Seven centres experienced in this type of work took part. The same hand held UV meter with two probes was sent in turn to each centre (International light IL1400A with a UVB probe SEL240/UVB-1 filter and UVA probe SCL033/UVA filter). For each probe there was a separate calibration factor stored within an EPROM. The calibration factors were chosen so that the meter reading was of the right order of magnitude, but the exact value of the factor was arbitrary. Each centre was asked to determine a correction factor needed to multiply the meter reading by to obtain the correct irradiance reading for each probe. They were asked not to adjust their standard method for this exercise. For the UVA probe broad band UVA phototherapy lamps were used, whereas narrow band UVB lamps (TL01) were used for the UVB probe. The meter was returned to the supplier who checked its operation before being passed on to the next centre. The survey took about 6 months to complete.

Results

The table below shows the correction factors obtained by each centre. The percentage difference from the mean is also shown. The coefficient of variation of the factors was 29,8 % for the UVB probe and 9,4 % for the UVA probe.

	Correction factor		(% factor difference from mean)	
Centre	TL01	TL09	TL01	UVA
Newcastle	0,48	1,52	20	9
London	0,52	1,52	30	9
Gloucester	0,33	1,2	-18	-14
Dundee	0,44	1,3	10	-7
Manchester	0,19	1,36	-53	-3
Edinburgh	0,5	1,54	25	10
Glasgow	0,34	1,34	-15	-4

Discussion

The results of this preliminary survey suggest that there is need for further work towards achieving greater consistency between centres. The results for UVA are possibly just acceptable. However the results for TL01 show greater disparity and this is certainly unacceptable. At this stage it is not possible to determine which result is correct. Comparing the results to the mean is not supposed to indicate that the mean correction factor is correct; it is merely a way of scaling the results.

There are a number of factors to investigate to understand the reasons for the discrepancies found. In most centres meters are calibrated by reference to a calibrated spectroradiometer. This in turn is calibrated by reference to a standard lamp. There are many possible sources of error in this approach, namely:

- Detector angular response. This is important in this application since there may be a large difference in the size of calibration sources and lamp arrays used for treatment.
- Detector linearity. This may be an important issue for TL01 sources that have a very narrow spectrum.
- Bandwidth and sampling. If the spectroradiometer sampling interval is large compared to bandwidth error will arise for TL01.
- Definition of UV bands. There is some discrepancy between centres over the integration limits for different UV bands.
- Differences in standard lamps used.

It is not the intention in this paper to attempt to resolve these issues. It is intended that each centre will examine in practice and discussion between centres may identify some of the sources of error. It is then hoped that this exercise may be repeated and closer agreement may be found.

Acknowledgements

The assistance of Able Instruments in supplying and distributing the meter is gratefully acknowledged

Discussion centred on the possible sources of the large errors observed in meter calibration for TL01 cabins. These discrepancies are particularly worrying because of the increasing use of this type of tube type in phototherapy.

Geoff Lewis and Debbie Purfield (*Churchill Hospital, Oxford*) presented a comparison of UV meter measurements in phototherapy cabins. An extract from Debbie Purfield's report is given below.

The Medical Physics department at the Churchill Hospital is involved in phototherapy dosimetry and… [is].. engaged in a project comparing radiometers used to obtain tube irradiance. This survey included six phototherapy centres in the South East region. Most of the units combined UVA and UVB tubes but these were treated separately. The UVB tubes comprised three types: Philips TLO1 narrow band tubes and the Waldmann UV6 and UV21 broad band tubes. The Waldmann tubes have a different spectral content though the majority of its radiance is in the UV band. The survey incorporated 8 UVA and 7 UVB units. Three standard UV meters (IL1700 and IL1400 with their respective UVA and UVB detectors, from International Light and the Waldmann UV meter) were used at every centre together with the centre's own meter (the local meter) and if available, the internal meter of the unit. Thus, up to a maximum of 5 UV meters could be inter-compared in one survey. In this way, variations in patient irradiance can be evaluated from a particular unit and also compared to units in other phototherapy centres. The recently purchased radiometer (International Light IL1700 from Able Instruments) by the Medical Physics department was calibrated according to UKAS standard at St. Thomas' Hospital which is traceable to NPL standards. This calibration involved spectral and angular correction thus relating it to an extended source calibration. This meter was consequently used as the 'reference' meter from which the performance of other meters was compared to.

Table Ic. UVA meter comparison. Results averaged over all UVA cabinets

Meter	%	± SD
IL1700	100	0
IL1400	90	0,012
Waldmann	78	0,021
local meter	86	0,029
Internal meter	88	0,043

This initial pilot study does not provide sufficient evidence to state reasons for the variability of the meter calibration. It however does give an indication that a variability does exist due to calibration of the meters. It has served to highlight the need for the calibration centres to be more standardised and currently work is in progress through the NPL ORM club.

Nick Gulliver, (*Guy's & St Thomas' Hospital Trust, GSTT, London*), presented the results of a project to analyse possible reasons for the large reported differences in meter calibrations for TL01 tube measurements.

A recent audit of Scottish phototherapy centres has highlighted 100 % variations in the dosimetry in phototherapy treatment cabins employing narrow-band UVB (TL01) tubes which emit mainly at a wavelength of 311 nm. With the increasing use of this form of phototherapy there has been concern to establish the reason for such variation. This study has examined the possible influence on the variability of the spectral output of TL01 tubes. Currently used broadband UVB meters, manufactured by International Light Inc., have a responsivity that falls at the rate of about 6 %/nm at 311 nm. When these are used in TL01 cabins, slight shifts in spectral output will have a corresponding effect on the meter reading. Spectral shifts resulting from tube age, position along the length of the tube and the type of cabin in which the tube is mounted were examined using a spectradiometer. None of these sources of spectral shift generated metering errors of a magnitude that would account for the large reported variation between centres. By far the largest error (5 %) related to differences in the TL01 spectrum measured in different types of cabin, possibly resulting from the use of different reflector materials. A filter on loan from Able Instruments Ltd, having a smaller 311 nm responsivity gradient provided the expected improvement. The additional cost of such filters, however, is probably not justified in practice by the small improvement in accuracy compared with the much larger reported errors.

Dr A J Coleman, (*GSTT, London.*) gave a progress report on the Medical FIG plan to set up a new database of phototherapy source spectra. This database has been placed on a temporary web site:

http://www-pet.umds.ac.uk/~medphys

The plan to build-up this database had the full support of those present. Some criticisms on the format were received including the need to tidy up the data sets to exclude noise in the tail ends of the spectra. Problems associated with including this data on a larger ORM database were also discussed. Dr Coleman requested that anyone with spectral data on phototherapy sources (or any medical light source excluding lasers) to send it in (to andrew.coleman@gstt.sthames.nhs.uk) for inclusion. Details of the provenance of the data will be provided to allow users to form a judgement as to its reliability.

This was a successful meeting that was well attended. A significant number of delegates came from abroad for the meeting, and several of the key manufacturers of medical sources and measuring instruments attended the Medical FIG. We are grateful to UMIST for the facilities and hospitality and to Fiona Jones and others at NPL for the efficient organisation.

European Geophysical Society
XXVI General Assembly
Nice, France, 26 - 30 March 2001

ST8.04 Atmospheric ozone (co-sponsored by OA): Solar ultraviolet and ozone

The symposium contents:

- Long-term changes in solar UV radiation
- Factors affecting radiative transfer of UV radiation: ozone, clouds, aerosols, height and albedo
- Radiative transfer modelling
- Spaceborne UV applications
- UV scenarios
- Impacts of UV variations on photochemistry

Deadline for receiving abstracts: 01 December 2000

Further information: http://134.76.234.216/nice01pro/overview.htm

Ultraviolet film badges for personal exposure studies

For more than 25 years, the polymer film polysulphone has been used as a dosimeter for ultraviolet radiation. The film is normally mounted in cardboard holders - this constitutes a UV film badge - and worn on the lapel site. The basis of the technique is that on exposure to UVB radiation, the UV absorption of the film increases. This increase, measured at 330 nm before and after exposure in a conventional UV spectrophotometer, gives a measure of the erythemal dose received by the film badge. Applications of personal UV dosimetry include:

- sun exposure of children
- sun exposure from different leisure pursuits
- sun exposure from different occupations
- anatomical distribution of sunlight in humans and animals
- clinical photosensitivity studies
- UV exposure of patients from therapeutic light sources
- UV exposure of workers in industry

Availability

Polysulphone UV film badges can be ordered from:

Professor B L Diffey, Regional Medical Physics Department, Newcastle General Hospital, Newcastle NE4 6BE, UK

Tel: +44 191 273 1577 Fax: +44 191 226 0970

e-mail: b.l.diffey@ncl.ac.uk

***Price* (*ex VAT @ 17,5%*)**

£1,20 per badge £110,00 for a box of 100 badges

If you do not have access to a spectrophotometer, we can read the initial and final absorbances and determine the erythemal doses. This applies only to badges exposed to sunlight; we cannot offer this service for badges exposed to artificial sources of UV. The cost for this service is £4,00 per badge (includes the cost of the badge).

NPL Optical Radiation Measurement Club

With the forthcoming end of the EU's Network on Ultraviolet Measurements readers may be interested in the UK's Optical Radiation Measurement (ORM) Club is partly funded by the UK Government's National Measurement System Policy Unit to assist in the transfer of knowledge. Although set up primarily to assist UK organisations it is pleased to accept members worldwide. The ORM Club aims to bring together all those with an interest in Optical Radiation Measurement, allowing unique opportunities for discussion and cross-fertilisation of ideas to address measurement issues that fall across industrial sectors. Membership includes instrument makers and users, industrial companies ranging from the smallest specialist manufacturers to large multinational companies, hospital medical physics departments and universities. Regular scientific meetings are held on topics of interest to the members. The high level of support for this initiative is reflected by the many diverse industrial sectors represented within the Club, and the number of people that attend meetings. Unfortunately, unlike the Thematic Network, members do not receive financial support to attend meetings.

What are the benefits of membership?

As a member of the ORM Club you will:

- be entitled to attend Club meetings free of charge (the number of delegates you can send depends on the type of membership)
- be able to meet with colleagues in the optical radiation measurement field, to exchange ideas and information
- gain information about new measurement techniques and measurement best practice, being developed at NPL and elsewhere
- have the opportunity to influence the development of new standards and techniques as part of the UK government's Optical Programme
- be regularly updated on international activities relating to optical radiation measurement

Focused Interest Groups (FIGs)

Much of the work of the Club in arranging meetings and addressing particular measurement problems is carried out via Focused Interest Groups (FIGs). Currently, there are six of these:

- Spectrophotometry and Colorimetry
- Ultra Violet Measurements
- Performance monitoring of surface colour measuring instruments (working group)
- Surface reflectance and colour for architects and lighting designers (working group)
- Solar optical properties of materials
- Medical Physics

While the UV measurement FIG is the only group exclusively dedicated to the UV the medical physics and solar optical properties groups have a strong interest in the UV. The aims of the FIGs are varied: some exist to produce specific documents such as recommendations or best practice guides, while others have the looser objective of sharing ideas and experience. Clearly these aims are likely to change over time.

Further information:
Fiona Jones
ORM Club Secretary
National Physical Laboratory
Queens Road, Teddington
Middlesex, TW11 0LW
UK

Telephone: +44 20 8943 6743
Telefax: +44 20 8943 6283
E-mail: fiona.jones@npl.co.uk
http://www.npl.co.uk/

Members are also welcome to propose new FIGs.

What is the membership fee?

There are three different membership categories. These are:

- Organisation (send up to 4 people to meetings) £625 per year
- Individual (send any one person to meetings) £250 per year
- Academic/Health Authority (send up to 4 people to meetings) £250 per year

Club fees are due in June each year, just before the Annual Meeting, which is free of charge, but members will have to pay for dinner and accommodation. Other meetings organised by the Club are also free of charge to members. ORM Club meetings are open to non-members on payment of a fee.

Service Card

Receiver: Helsinki University of Technology

Petri Kärhä

Telefax: +358 - 9 - 451 2222

☐ Remove me from your mailing lists and do not send me material related to the Thematic Network for Ultraviolet Measurements anymore.

☐ Add me to your mailing lists and send me material related to the Thematic Network for Ultraviolet Measurements in the future.

☐ I would be interested to join the Working group Nr. 1 2 3 4 (circle)

☐ Update my contact information

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